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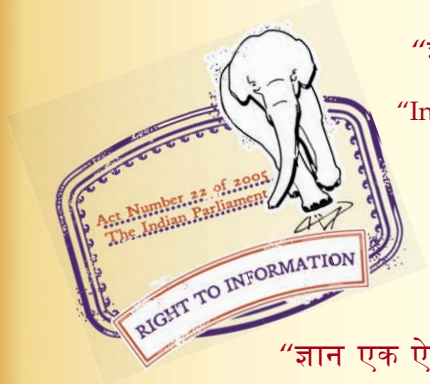
IS 4633 (1968): Fixed Metallized-paper Dielectric Capacitor for Direct Current [LITD 5: Semiconductor and Other Electronic Components and Devices]



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"Knowledge is such a treasure which cannot be stolen"

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IS : 4633 - 1968

Indian Standard

SPECIFICATION FOR FIXED METALLIZED-PAPER DIELECTRIC CAPACITOR FOR DIRECT CURRENT

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Indian Standard

SPECIFICATION FOR FIXED METALLIZED-PAPER DIELECTRIC CAPACITOR FOR DIRECT CURRENT

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(*Continued on page 2*)

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Indian Standard

SPECIFICATION FOR FIXED METALLIZED-PAPER DIELECTRIC CAPACITOR FOR DIRECT CURRENT

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 10 May 1968, after the draft finalized by the Capacitors and Resistors for Electronic Equipment Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This standard relates to fixed metallized-paper dielectric capacitors for direct current containing a dielectric of impregnated paper and thin deposited metal electrodes, intended for use in electronic and telecommunication equipment.

0.3 The object of this standard is to establish uniform requirements for judging the electrical, mechanical and climatic properties of capacitors, to describe test methods and to give recommendations for classification into categories according to their ability to withstand the conditions as specified in IS : 589-1961*.

0.4 While preparing this standard, assistance has been derived from the following:

IEC Pub 166 Fixed metallized-paper dielectric capacitors for direct current. International Electrotechnical Commission.

B.S. 2136 :1965 Specification for fixed metallized-paper dielectric capacitors for direct current. British Standards Institution.

0.5 This standard requires reference to IS : 589-1961* in which details of the various climatic and mechanical tests prescribed in this standard have been covered. Only the appropriate degrees of severity requirements and any other special conditions relating to climatic and mechanical tests have been included in this standard.

0.6 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960†. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

*Basic climatic and mechanical durability tests for electronic components (*revised*).

†Rules for rounding off numerical values (*revised*).

1. SCOPE

1.1 This standard prescribes the requirements and methods of tests for judging the electrical, mechanical and climatic properties of fixed capacitors with self-healing properties, for direct current, with a rated voltage not exceeding 6 300 V, containing a dielectric of impregnated paper and thin deposited metal electrodes, generally intended for use in electronic and telecommunication equipment.

1.1.1 This standard does not cover capacitors for radio frequency interference suppression (*see* IS : 3723-1966*).

1.1.2 Dimensional requirements of capacitors are not included in this standard.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 dc Capacitors — A capacitor designed essentially for application with a direct voltage.

2.2 Self-Healing — A process by which the electrical properties of a capacitor after a local breakdown of its dielectric are instantaneously and essentially restored to their values before the breakdown.

2.3 Metallized-Paper Dielectric Capacitor, Type 1 — Capacitors in which the number of local breakdowns and self-healing operations during service shall be negligible.

NOTE — The criterion for classification as Type 1 and Type 2 is given in **7.7.**

2.4 Metallized-Paper Dielectric Capacitor, Type 2 — Capacitors for which the self-healing of the metallized dielectric at voltages both below and above the rated voltage is generally relied upon to provide protection for a capacitor in normal use.

NOTE — The criterion for classification as Type 1 and Type 2 is given in **7.7.**

2.5 Rated Voltage (U_R) — The direct operating voltage that can be continuously applied to the terminals of a capacitor at an ambient temperature of 70°C.

2.6 Category Voltage (U_C) — The direct operating voltage that can be continuously applied to the terminals of a capacitor at the maximum temperature pertaining to the particular category.

2.7 Rated Capacitance — The value of the capacitance indicated by the manufacturer and marked on the capacitor.

*Specification for capacitors for radio interference suppression.

2.8 Rated Temperature Range — The range of ambient temperatures for which the capacitor is designed for continuous operation; this corresponds with the temperature limits of its appropriate category.

2.9 Tangent of Loss-Angle (Tanδ) — The power loss of the capacitor divided by the reactive power of the capacitor at a sinusoidal voltage of specified frequency.

2.10 Type Tests — Tests carried out to prove conformity with the requirements of this standard. These are intended to prove the general quality and design of a given type of capacitor.

2.11 Acceptance Tests — Tests carried out on samples selected from a lot for the purpose of acceptance of the lot.

2.11.1 *Lot* — All capacitors of the same category and rating, manufactured by the same factory, during the same period.

2.12 Routine Tests — Tests carried out on each capacitor to check the requirements which are likely to vary during production.

3. CATEGORIES

3.1 Fixed metallized-paper dielectric capacitors shall belong to one of the three categories detailed in Table 1 below, based on their ability to withstand the corresponding climatic severities (*see also* IS : 589-1961*).

TABLE 1 CATEGORIES OF FIXED METALLIZED-PAPER DIELECTRIC CAPACITOR

Climatic Test	Severities		
	Category 1	*Category 2*	*Category 3*
Dry heat	+ 100°C	+ 85°C	+ 70°C
Cold	− 55°C	− 40°C	− 10°C
Damp heat (long term)	56 days	56 days	21 days
Damp heat (accelerated)	6 cycles	6 cycles	2 cycles
Rapid change of temperature	+ 100°C − 55°C	+ 85°C − 40°C	—
Low air pressure	44 mbar	300 mbar	600 mbar

Note — In case of special requirements when the above categories cannot be strictly applied, different combinations of severities may be agreed to between the purchaser and the manufacturer provided such degrees of severity are chosen from IS : 589-1961*.

*Basic climatic and mechanical durability tests for electronic components (*revised*).

4. RATINGS

4.1 Rated Capacitances and Tolerances

4.1.1 *Rated Capacitance* — The value of rated capacitance shall be chosen from E 6 series of IS : 824-1965*.

4.1.2 *Tolerances on Rated Capacitance* — The permissible tolerances on rated capacitance values shall be as follows:

± 5, ± 10 and ± 20 percent.

4.2 Rated Voltage — The standard values of rated voltages for the capacitors shall be:

63, 100, 125, 160, 200, 250, 400, 630, 1 000, 1 600, 2 500, 4 000 and 6 300 V.

NOTE — These values conform to the basic series of preferred values R5 given in IS : 1076-1957†, with the addition of the values 125 V and 200 V, chosen from the R10 series of the same standard. If other values are needed, they shall be chosen from the R10 series.

4.2.1 Where alternating voltages are present, whether or not in addition to the direct voltage, the working voltage of the capacitor shall be taken as the sum of the direct voltage and the peak alternating voltages. This sum shall not exceed the value of the rated voltage, and the value of the peak alternating voltage shall not exceed the following percentages of the rated direct voltage at the frequencies stated:

Frequency	*Percent*
50 c/s	20 (*see* Note)
100 c/s	15 (*see* Note)
1 000 c/s	3
10 000 c/s	1

NOTE — Only 10 percent of peak alternating voltage should be permitted where the rated voltage exceeds 1 500 V.

5. CONSTRUCTION AND WORKMANSHIP

5.1 Construction

5.1.1 *Terminals* — Unless otherwise specified, the terminals of the capacitors shall be either in the shape of screws, tags or wires and so coated as to be easily solderable. Each wire terminal shall be at least 38 mm long and of diameter between 0·5 and 1·00 mm.

5.2 Workmanship — All parts shall be manufactured in a thoroughly workmanlike manner and in accordance with good engineering practice.

*Preferred values for resistors and capacitors (*revised*).

†Preferred numbers.

6. MARKING

6.1 The capacitor shall be provided with the following information in the order as shown:

a) Rated capacitance in microfarads or in picofarads,
b) Rated voltage (U_R),
c) Indication of the connection to the outer foil (where applicable),

NOTE — This indication shall be made by a heavy type arrowhead pointing towards the outside termination or by any other suitable means.

d) Manufacturer's name or trade-mark,
e) Manufacturer's type number,
f) Tolerance on rated capacitance,
g) Week (or month) and year of manufacture (this may be in code form),
h) Category voltage (U_C) and indication of category according to this standard, and
j) Any other marking, as agreed to between the manufacturer and the purchaser.

NOTE — If coded marking of values and their tolerances by means of letters and digits are used, it shall be in accordance with IS : 4114-1967*.

6.2 The capacitors shall be clearly marked with (a), (b), (c), (d) and (e) of **6.1** and with as many as possible of the remaining items, as agreed to between the manufacturer and the purchaser.

6.2.1 The carton containing the capacitor(s) shall be clearly marked with all the items specified in **6.1**.

6.3 The markings shall be such as not to become illegible during service through reasonable handling and while in storage. A transparent protective coat or other suitable means may be used to ensure this.

6.4 Any additional marking on the capacitor or on its carton or on both shall be applied as not to cause confusion.

6.4.1 The capacitors may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act and the Rules and Regulations made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

*Coded markings of values of capacitance and resistance by letters and digits.

7. TESTS

7.1 Classification of Test

7.1.1 *Type Tests* — The procedure for type approval shall be in accordance with IS : 2612-1965*. Unless otherwise agreed, the manufacturer shall submit 36 samples of each category, rating and type of capacitors.

The capacitors shall be equally divided between:

a) the maximum capacitance at its highest appropriate working voltage, and

b) the maximum working voltage at its highest appropriate capacitance.

The samples shall be divided as specified below among the different lots given in Appendix A :

Lot	*From Each Case Size*	
	Maximum Capacitance	Maximum Voltage
1	2	2
2	2	2
3	2	2
4	1	1
5	1	1
6	1	1

NOTE — When only one case size is submitted for type approval, the minimum number shall be 36. The samples for each lot shall then be double the values given above.

The sequence of type tests shall be in accordance with Appendix A.

7.1.2 *Acceptance Tests* — The acceptance tests shall be carried out on a limited number of samples selected in accordance with the sampling plan given in IS : 2612-1965* and which have passed the routine tests (*see* 7.1.3). Two groups of samples, one for non-destructive tests (Group A) and the other for destructive tests (Group B), shall be selected (*see* Appendix B of IS : 2612-1965*) and the capacitors in each group shall be subjected to the tests specified below:

Group A (Non-destructive)

a) Dimensions (7.4.2),

b) Voltage proof (High Voltage) (7.3.3),

c) Insulation resistance (7.3.4), and

d) Outer foil marking (where applicable) (7.3.6).

*Recommendation for type approval and sampling procedures for electronic components.

Group B (Destructive)

a) Robustness of terminations (7.4.3),
b) Soldering (7.4.4), and
c) Climatic sequence (7.5.1).

7.1.3 *Routine Tests* — The following tests shall be carried out on each and every capacitor:

a) Visual examination (7.4.1),
b) Capacitance (7.3.1), and
c) Voltage proof (High Voltage) (as a flash test) (7.3.3).

7.2 General Conditions for Tests

7.2.1 *Selection of Samples* — The samples for tests shall be so selected as to be representative of the range of capacitances value, voltage rating and category of the type under consideration.

7.2.2 *Atmospheric Conditions for Tests* — Unless otherwise specified, all tests shall be carried out under standard atmospheric conditions for testing as specified in IS : 589-1961*.

7.2.3 *Preconditioning* — Before measurements are made, the capacitors shall be stored at the measuring temperature and relative humidity for sufficient time to allow the entire capacitor to reach these conditions. The recovery period called for after climatic conditioning is adequate for this purpose.

7.2.4 *Corrections to be Applied* — When measurements are made at temperatures other than the specified temperature, the result shall, where necessary, be corrected to the specified temperature. The ambient temperature during the tests shall be stated in the test report.

7.2.5 *Other Precautions* — During measurements, the capacitors shall not be exposed to draughts, direct sunlight or other influences likely to cause error.

7.3 Electrical Tests

7.3.1 *Capacitance* — The capacitance shall be measured at a frequency of:

a) For capacitors with a rated capacitance over 1 µF and rated voltage over 3 000 V	40-60 c/s
b) For all other capacitors	800-1200 c/s

7.3.1.1 The applied voltage shall not exceed the limits laid down in 4.2.1 with maximum of 100 V.

*Basic climatic and mechanical durability tests for electronic components (*revised*).

The measuring method shall be such that the error does not exceed:

a) ten percent of the rated capacitance tolerance for absolute capacitances measurements, and

b) ten percent of the specified maximum change of capacitance for measurements of variation of capacitance.

The capacitance value shall correspond with the rated capacitance taking into account the rated tolerance.

7.3.2 *Tangent of Loss Angle* — When measured under the conditions of **7.3.1** with an instrument accurate to 0·001, the tangent of loss angle shall not exceed 0·015.

NOTE — Each section of multiple section capacitors shall be treated as a separate capacitor for the measurement of tangent of loss angle.

7.3.3 *Voltage Proof (High Voltage)* — A dc test voltage of the value specified below shall be applied for a period of one minute, the voltage being applied between the parts specified therein:

a) *For single section capacitors*	
1) Between terminations	1·5 U_R
2) Between terminations connected together and the case (except where the case is one of the terminations) or the metal plate	2·0 U_R with a minimum of 200 V
b) *For multiple section capacitors having a common termination for all sections*	
1) Between each of the terminations and the common termination	1·5 U_R
2) Between all terminations connected together and the case (except where the case is one of the terminations) or the metal plate (*see* below)	2·0 U_R with a minimum of 200 V
3) Between the non-common terminations of each section and all the other terminations connected together	1·5 U_R
c) *For multiple section capacitors with no common terminations*	
1) Between the termination of each section	1·5 U_R
2) Between all terminations connected together and the case or the metal plate (*see* below)	2·0 U_R with a minimum of 200 V
3) Between terminations of separate sections, the two terminations of each section being connected together	2·0 U_R with a minimum of 200 V

Where the case of the capacitor is non-metallic or where the capacitor has a metallic case with an insulating sleeve, the capacitor shall be mounted in its normal position on a metal plate, which extends at least 12·5 mm beyond the mounting face of the capacitor in all directions; the test voltage shall be applied between the terminations connected together and the metal plate.

The circuit for this test shall be so chosen that the voltage is applied immediately through the internal resistance of the test apparatus. The product of this internal resistance and the rated capacitance value of the capacitor under test plus any parallel capacitance in the test apparatus shall not exceed one second. The charging current shall not exceed one ampere.

A suitable circuit for this test is given in Appendix B.

After the voltage proof test, there shall be no breakdown flashover of capacitor, nor any visible deterioration, such as overheating.

To discharge the capacitor fully, it shall then be short-circuited for about 24 hours.

When this test is conducted as a routine test, the voltage may be applied as a flash, say for a period of one second only.

7.3.4 *Insulation Resistance* — The insulation resistance shall be measured between the parts specified in Table 2 and meet the requirements specified therein.

Where the case of the capacitor is non-metallic or where the capacitor has a metallic case with an insulating sleeve, the capacitor shall be mounted in its normal position on a metal plate, which extends at least 12·5 mm beyond the mounting face of the capacitor in all directions; the test voltage shall be applied between the terminations connected together and the metal plate.

Before the measurement of insulation resistance, the capacitor shall be fully discharged. The insulation resistance shall be measured with a dc voltage equal to:

a) For capacitors with rated voltage less than 100 V	10 ± 1 V
b) For capacitors with rated voltage equal to or greater than 100 V, but less than 500 V	100 ± 15 V
c) For capacitors with rated voltage equal to or greater than 500 V	500 ± 50 V

The dc voltage shall be applied for one minute ± 5 seconds. The voltage shall not be applied gradually but at once through the internal resistance of the test apparatus. The product of this internal resistance in ohms and the rated capacitance in farads shall not exceed one second.

TABLE 2 INSULATION RESISTANCE MEASUREMENTS

(*Clause* 7.3.4)

Measuring Points	Requirement (Ref Column No. Below)
a) For single section capacitor:	
1) Between terminations	I
2) Between terminations connected together and the case (except where the case is one termination) or the metal plate (*see* below)	II
b) For multiple section capacitor having a common termination for all sections:	
1) Between each of the terminations and the common termination	I
2) Between all terminations connected together and the case (except where the case is one of the terminations) or the metal plate (*see* below)	*See* Note
3) Between the non-common terminations of each section and all the other terminations connected together	I
c) For multiple section capacitor having no common termination:	
1) Between the terminations of each section	I
2) Between all terminations connected together and the case or the metal plate (*see* below)	*See* Note
3) Between terminations of separate sections the two terminations of each section being connected together	II

Note — Values of column II divided by the number of sections.

Type	Column I Between Terminations of Each Section		Column II Between Termination and Case and Between Elements		
	Rated Capacitances Up to and Including 0·33 μF	*Rated Capacitance Exceeding* 0·33 μF	*Minimum Resistance* MΩ		
	Minimum resistance MΩ	Minimum *RC* product seconds	Category I	Category II	Category III
Type I	3 000	$\frac{250}{C} + 250$	12 000	12 000	6 000
Type II	1 200	$\frac{100}{C} + 100$	12 000	12 000	6 000

Note — In the above table, C is the rated capacitance in microfarads and R the measured insulation resistance in megohms.

The insulation resistance value shall, if necessary, be corrected by multiplying the result of measurement by the appropriate correction factor chosen from the values given below:

Temperature °C	*Correction Factor*
15	0·71
16	0·76
17	0·81
18	0·87
19	0·93
20	1·00
21	1·07
22	1·15
23	1·23
24	1·32
25	1·41
26	1·52
27	1·62
28	1·74
29	1·87
30	2·00
31	2·14
32	2·30
33	2·46
34	2·64
35	2·83

NOTE — This table is based on the formula:

$$R_{20} = R_t \times 2^{\left(\frac{t-20}{10}\right)}$$

where

R_{20} = insulation resistance at 20°C, and

R_t = insulation resistance measured at temperature t°C.

7.3.5 *Inductance* (*Where Applicable*) — The inductance of the capacitor shall not be greater than that of a wire of 0·20 mm in diameter and of a length equal to that of the capacitor plus the minimum amount of lead required to connect the capacitor to the test apparatus. The total length of the connecting lead shall not exceed the length of the body of the capacitor.

The measuring frequency shall be so chosen that the inductive reactance is at least ten times the capacitive reactance. A suitable test method for the measurement is specified in Appendix C.

7.3.6 *Outer Foil Indication (Where Applicable)* — The correct indication of the termination which is connected to the outside metal foil shall be checked in such a way that the capacitor is not damaged. A suitable method is specified in Appendix D.

7.3.7 *Self-healing* — For testing the self-healing properties of a capacitor, the capacitor shall be subjected to a number of electrical breakdowns, using a limited amount of energy for the breakdown. The properties of the capacitor shall then be measured again.

The application of the test method and the requirements shall be agreed to between the purchaser and the manufacturer.

A suitable test method is given in Appendix E.

7.4 Mechanical Tests

7.4.1 *Visual Examination* — The capacitors shall be visually examined for compliance with the requirements specified in **5** and **6**.

7.4.2 *Dimensions* — The dimensions of capacitors shall be checked and shall comply with the specified values.

7.4.3 *Robustness of Terminations*

7.4.3.1 *Tensile test* — This test shall be carried out in accordance with **7.19.1** of IS : 589-1961*, the loading weight being as follows:

a) For all types of terminations except wire terminations — 2·0 kg

b) For wire terminations:

Cross-Sectional Area of Wire mm²	*Load* kg
Exceeding 0·5	2
Exceeding 0·2, up to and including 0·5	1
Up to and including 0·2	0·5

There shall be no visible damage to the capacitor after this test.

7.4.3.2 *Bending test*

a) *Wire terminations* — The bending test on wire terminations shall be carried out in accordance with **7.19.2.2** of IS : 589-1961*. Care shall be taken to ensure that the bend occurs at a point 6 mm away from the point of emergence of the wire from the capacitor and around a radius of 0·75 mm. A suitable arrangement to

*Basic climatic and mechanical durability tests for electronic components (*revised*).

ensure this requirement is shown in Fig. 1. Each termination shall withstand two consecutive bends without visible damage to the capacitor.

NOTE — This test shall be carried out on one-half of the terminations while the torsion test (*see* **7.4.3.3**) shall be carried out on the other half terminations.

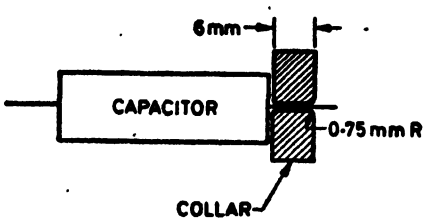

FIG. 1 ARRANGEMENT FOR BENDING TEST

b) *Tag terminations* — The bending test on tag type terminations shall be carried out in accordance with **7.19.2.3** of IS : 589-1961*. Each soldering tag shall withstand two consecutive cycles of bending without visible damage to the capacitor.

7.4.3.3 *Torsion test*

a) *Wire terminations* — This torsion test on wire termination shall be carried out in accordance with **7.19.3** of IS : 589-1961*. Two successive rotations shall be performed and there shall be no visible damage to the capacitor.

b) *Nuts and threaded terminations* — The torsion test on nuts and threaded terminations shall be carried out in accordance with **7.19.4** of IS : 589-1961*. There shall be no visible damage to the capacitor after this test.

7.4.4 *Soldering* — The capacitor shall be subjected to the solder bath test specified in **7.18.2** of IS : 589-1961*. In the case of capacitors stated by the manufacturer to be suitable for use with printed wiring, the wire terminations shall be immersed up to 3·5 mm from the point where the termination emerges from the body of the capacitor.

NOTE — For capacitors with tag terminations, the soldering iron test in accordance with **7.18.3** of IS : 589-1961* may be applied, in case the solder bath test is not practicable.

After application of the solder bath test, the capacitors shall be visually examined and there shall be no visible damage.

*Basic climatic and mechanical durability tests for electronic components (*revised*).

7.4.5 *Vibration Test* — The capacitors shall be subjected to the vibration (fatigue) test in accordance with **7.6.6** of IS : 589-1961*, with the following severities:

Categories 1 and 2	Severity III (*see* Table 2 of IS : 589-1961*)
Category 3	Severity I (*see* Table 2 of IS : 589-1961*)

The capacitors shall be mounted in accordance with **7.6.4.1** of IS : 589-1961* taking care that the terminal wires are not stressed and in such a manner that equal numbers are vibrated along each of the three principal axes.

The capacitors shall then be visually examined and there shall be no visible damage or any mechanical deterioration.

The capacitance and tangent of loss angle shall be measured and there shall be no change in the values of capacitance and the tangent of loss angle, when compared with the values measured in **7.3.1** and **7.3.2.**

7.4.6 *Bump Test* — The capacitors shall be subjected to the bump test in accordance with **7.5.1** of IS : 589-1961*. The capacitors shall be mounted as specified in **7.4.5** and in such a manner that equal numbers are bumped along the three principal axes.

The capacitors shall then be visually examined and there shall be no visible damage or any mechanical deterioration.

The capacitance shall then be measured. The change of capacitance compared with the value measured in **7.3.1** shall not exceed 5 percent.

7.4.7 *Container Sealing (Where Applicable)* — The capacitors shall be subjected to the procedure of **7.16.2** Test B of IS : 589-1961*.

NOTE — The method of detection is under consideration.

7.5 Climatic Tests

7.5.1 *Climatic Sequence*

7.5.1.1 *Initial measurements* — The capacitance shall be measured.

7.5.1.2 *Dry heat* — The capacitors shall be subjected to dry heat test in accordance with **7.2** of IS : 589-1961*, the temperature of the test chamber being maintained at the appropriate upper category temperature.

At the end of the specified period and while still at high temperature, the capacitance and insulation resistance shall be measured. The change of capacitance when compared with the value measured in **7.5.1.1**, shall not exceed 10 percent. The insulation resistance shall conform to the value specified in Table 3.

*Basic climatic and mechanical durability tests for electronic components (*revised*).

TABLE 3 INSULATION RESISTANCE DURING DRY HEAT TEST

(*Clause* 7.5.1.2)

Type and Category	Between Terminations of Each Section		Between Terminations and Case and Between Elements
	Rated Capacitance Up to and Including 0·33 μF	*Rated Capacitance Exceeding* 0·33 μF	
	Minimum resistance MΩ	Minimum RC product seconds	Minimum resistance MΩ
Type 1			
Category 1	12	$\frac{1}{C}+1$	47
Category 2	33	$\frac{2{\cdot}5}{C}+2{\cdot}5$	130
Category 3	93	$\frac{8}{C}+8$	180
Type 2			
Category 1	5	$\frac{0{\cdot}4}{C}+0{\cdot}4$	47
Category 2	13	$\frac{1}{C}+1$	130
Category 3	37	$\frac{3{\cdot}3}{C}+3{\cdot}3$	180

NOTE — In the above table, C is the rated capacitance in microfarads and R the measured insulation resistance in megohms.

The insulation resistance shall be measured with a direct voltage as specified below:

Category Voltage of the Capacitors	*Measuring Voltage*
V	V
$U_c<100$	10 ± 1
$100 \leqslant U_c<500$	100 ± 15
$U_c \geqslant 500$	500 ± 50

After recovery, the capacitors shall be visually examined. There shall be no visible damage or seepage of impregnant.

7.5.1.3 *Damp heat (accelerated) first cycle* — The capacitors shall be subjected to the first cycle of damp heat (accelerated) test, in accordance with **7.4** of IS : 589-1961*.

After recovery, the capacitors shall be immediately subjected to the cold test.

7.5.1.4 *Cold* — The capacitors shall be subjected to the cold test in accordance with **7.1** of IS : 589-1961*. The temperature of the test chamber being maintained at the appropriate lower category temperature and the duration of the exposure shall be one and a half hours.

The capacitance value shall be measured while the capacitors are still in the cold chamber and the change in capacitance value shall not exceed 10 percent when compared with the value measured in **7.5.1.1.**

The capacitors shall then be removed from the cold chamber and visually examined. There shall be no apparent damage. The markings shall be legible and indelible. The capacitors shall remain under recovery conditions for 2 to 4 hours. They shall then be removed from the chamber and shaken by hand to remove droplets of water.

7.5.1.5 *Low air pressure* — The capacitors shall be subjected to the low air pressure test in accordance with **7.12** of IS : 589-1961*. The test chamber shall be maintained at an air pressure appropriate to the category and in a temperature range of 15° to 35°C. The duration of the exposure shall be one hour.

While still at the specified low pressure and during the last 5 minutes of the one hour period, the voltage proof test shall be carried out. The test voltage shall be applied to the terminations, case, etc, as specified in **7.3.3.** The lot of capacitors submitted to this test shall be subdivided into two or three parts as necessary and each part submitted to one of the test (a), (b) and (c) specified in **7.3.3.** The value of the test voltage will depend on the construction of the capacitor, and it shall be agreed between the customer and the manufacturer.

During and after this test, there shall be no sign of permanent breakdown, flashover, harmful deformation of the case, or seepage of impregnant.

7.5.1.6 *Damp heat (accelerated) remaining cycles* — The capacitor shall be subjected to the remaining cycles of the damp heat (accelerated) test in accordance with **7.4** of IS : 589-1961*. The number of cycles shall be appropriate to the category.

NOTE — The remaining number of damp heat (accelerated) cycles are as follows:

Category 1	5
Category 2	5
Category 3	1

*Basic climatic and mechanical durability tests for electronic components (*revised*).

After recovery the capacitors shall be visually examined. There shall be no visible damage and the marking shall be legible.

7.5.1.7 *Final measurements* — The capacitance, the tangent of loss angle and the insulation resistance shall be measured.

The change of capacitance compared with the value measured in **7.5.1.1** shall not exceed 5 percent.

The tangent of loss angle shall not exceed the value specified in **7.3.2** or 1·2 times the value measured in **7.3.2**, whichever is the greater.

The insulation resistance shall fulfil the following requirements:

Type and Category	Between Terminations of Each Section		Between Terminations and Case and Between Elements
	Rated Capacitance Up to and Including 0·33 μF	*Rated Capacitance Exceeding* 0·33 μF	
	Minimum resistance MΩ	Minimum RC product seconds	Minimum resistance MΩ
Type 1			
Categories 1 and 2	3 000	$\frac{250}{C} + 250$	12 000
Category 3	1 500	$\frac{125}{C} + 125$	3 000
Type 2			
Categories 1 and 2	1 200	$\frac{100}{C} + 100$	12 000
Category 3	600	$\frac{50}{C} + 50$	3 000

NOTE — In the above table, C is the rated capacitance in microfarads and R the measured insulation resistance in megohms.

7.5.2 *Damp Heat (Long Term Exposure)* — The capacitors shall be subjected to this test in accordance with **7.3** of IS : 589-1961*, using the appropriate degree of severity under the following conditions:

a) First half of lot — no voltage applied during exposure

b) Second half of lot — 2 V applied during exposure

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After recovery the capacitors shall be visually examined. There shall be no visible damage and the marking shall be legible.

For the first half of the lot, the capacitance, the tangent of loss angle and the insulation resistance shall then be measured. The change of capacitance compared with the value measured in **7.3.1** shall not exceed 5 percent. The tangent of loss angle shall not exceed the value specified in **7.3.2** or 1·2 times the value measured in **7.3.2**, whichever is greater. The insulation resistance shall fulfil the following requirements:

Type and Category	Between Terminations of Each Section		Between Terminations and Case and Between Elements
	Rated Capacitance Up to and Including 0·33 μF	*Rated Capacitance Exceeding* 0·33 μF	
	Minimum resistance MΩ	Minimum RC product seconds	Minimum resistance MΩ
Type 1			
Categories 1 and 2	3 000	$\frac{250}{C} + 250$	12 000
Category 3	1 500	$\frac{125}{C} + 125$	3 000
Type 2			
Categories 1 and 2	1 200	$\frac{100}{C} + 100$	12 000
Category 3	600	$\frac{50}{C} + 50$	3 000

NOTE — In the above table, C is the rated capacitance in microfarads and R the measured insulation resistance in megohms.

For the second half of the lot, the insulation resistance between terminations shall be measured with a dc voltage not exceeding 2 V. The insulation resistance shall be not less than 1MΩ.

7.5.3 *Rapid Change of Temperature* — This test is applicable to categories 1 and 2 only.

The capacitance shall be measured.

The capacitors shall be subjected to one cycle of rapid change of temperature test in accordance with **7.14** of IS : 589-1961*. The upper

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temperature shall be the appropriate upper category temperature, while the lower temperature shall be the appropriate lower category temperature.

After recovery, the capacitors shall be visually examined. There shall be no visible damage.

The capacitance and tangent of loss angle shall then be measured. The change of capacitance compared with the value measured above shall not exceed 5 percent. The tangent of loss angle shall not exceed the value specified in **7.3.2.**

7.5.4 *Salt Mist* — The capacitors shall be subjected to salt mist test in accordance with **7.10** of IS : 589-1961*. The duration of the exposure shall be four days.

After recovery, the capacitors shall be visually examined. There shall be no visible damage and the marking shall be legible.

7.5.5 *Mould Growth* — This test shall be carried out in accordance with **7.9** of IS : 589-1961* and shall satisfy the requirements specified therein.

7.6 Storage (Normal) Test — The capacitors shall be subjected to this test in accordance with **7.8.1** of IS : 589-1961*. At the end of the storage for the specified period, the capacitors shall be visually examined. There shall be no visible damage and the marking shall be legible. The capacitance, tangent of loss angle and insulation resistance shall then be measured (limits are under consideration).

7.7 Endurance Test — The capacitors shall be submitted to an endurance test of 1 000 hours at the relevant upper category temperature with a dc voltage applied as specified below:

a) First half of the lot	1·25 times the category voltage, applied to each capacitor through a resistor whose value is approximately equal to 1 ohm per applied volt
b) Second half of the lot	2 V

A capacitor shall be considered to have failed when a permanent short-circuit or open circuit occurs in any section of the capacitor or when a short-circuit occurs between an electrode and the case.

During the test period, the number of self-healing failures of capacitors in the first half of the lot shall not exceed the following limits:

Type 1: $25 \times C$ per capacitor where C is in microfarads, for capacitance values greater than 0·1 μF and two failures per capacitor for capacitance values of 0·1 μF and less.

Type 2: $500 \times C$ per capacitor where C is in microfarads, for capacitance values greater than 0·1 μF and 50 failures per capacitor for capacitance values of 0·1 μF and less.

*Basic climatic and mechanical durability tests for electronic components (*revised*).

Suitable sensitivity and time-constant data for the test apparatus are given in Appendix F.

The details of the test method shall be agreed between the purchaser and the manufacturer.

The capacitors shall be placed in the test chamber in such a manner that no capacitor is within 25 mm of any other capacitor. The capacitors shall not be heated by direct radiation and the circulation of the air in the chamber shall be sufficient to prevent the temperature from departing by more than 3°C from the specified temperature of the chamber, at any point where the capacitor may be placed. It shall be assumed in this test that the temperature of the capacitors is the same as the specified temperature of the chamber.

After the specified period, the capacitors shall be allowed to cool to standard atmospheric conditions for testing.

The capacitors shall then be visually examined. There shall be no visible damage.

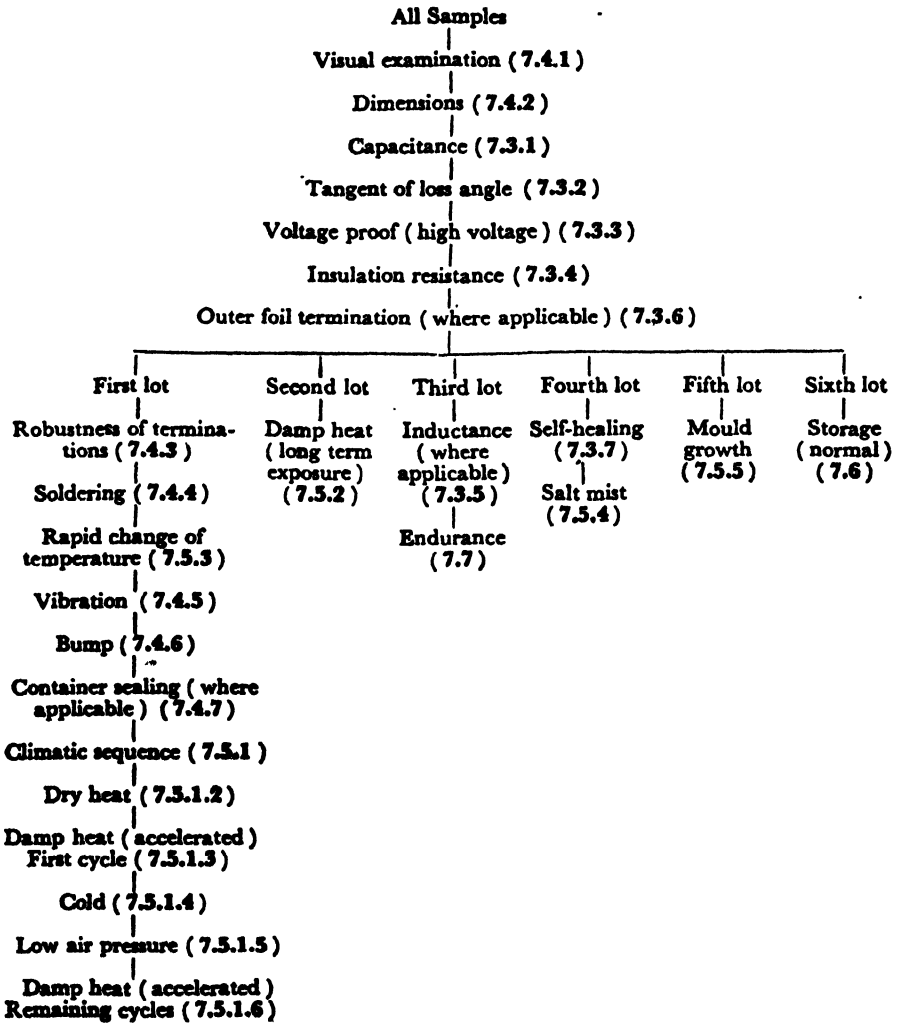
For the first half of the lot, the capacitance, the tangent of loss angle and the insulation resistance shall then be measured. The change of capacitance compared with the value measured in **7.3.1** shall not exceed 5 percent for Type 1 and 10 percent for Type 2 capacitors. The tangent of loss angle shall not exceed the value specified in **7.3.2** or 1·4 times the value measured in **7.3.2** whichever is greater. The insulation resistance shall not be less than half the values specified in **7.3.4.**

For the second half of the lot, the insulation resistance between terminations shall be measured with a dc voltage not exceeding 2 V. The insulation resistance shall not be less than 1 MΩ.

APPENDIX A

(*Clause* 7.1.1)

SCHEDULE OF TYPE TESTS



APPENDIX B

(*Clause* 7.3.3)

TEST CIRCUIT FOR VOLTAGE PROOF (HIGH VOLTAGE) TEST

B-1. CIRCUIT

B-1.1 A suitable circuit for the voltage proof (high voltage) test is given in Fig. 2.

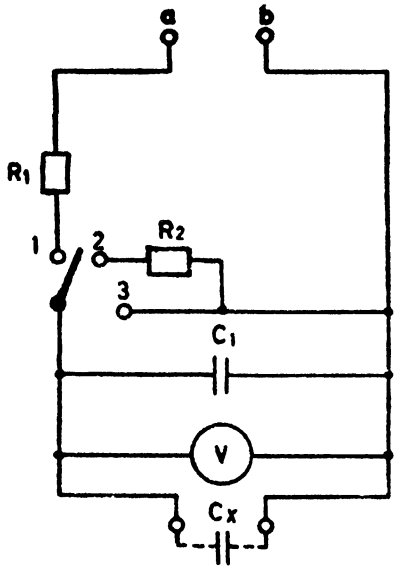


FIG. 2 SUITABLE CIRCUIT FOR THE VOLTAGE PROOF TEST

B-1.1.1 The resistance of the voltmeter shall be not less than 10 000 ohms/volt.

B-1.1.2 The capacitance C_1 shall be at least ten times that of C_x.

B-1.1.3 The resistance R_1 and R_2 shall be such that the initial charging and discharging current of C_x does not exceed 5 mA for capacitors of capacitance value less than 100 pF, and 50 mA, for capacitors of capacitance value 100 pF and above at the highest test voltage.

Further, R_1 and R_2 should have a value such that

$$R_1 (C_1 + C_x) \leqslant 1 \text{ second}$$

$$R_2 (C_1 + C_x) \leqslant 1 \text{ second}$$

in which C_1 and C_x are in farads and R_1 and R_2 in ohms.

B-1.1.3.1 R_1 includes the internal resistance of the power supply also.

B-2. PROCEDURE

B-2.1 The switch shall be connected to R_2. The two terminals indicated as *a* and *b* in the diagram, shall be connected to a variable dc supply of adequate power which shall be adjusted to the required test voltage.

B-2.2 The switch shall then be connected to R_1 so that the capacitors C_1 and C_x are charged.

B-2.3 The switches shall remain in this position for the time specified in **7.3.3** after the test voltage has been reached. The capacitors shall then be discharged by connecting the switch to R_2.

B-2.4 As soon as the voltmeter reading has fallen to zero, the capacitors shall be short-circuited and C_x shall be disconnected.

APPENDIX C

(Clause 7.3.5)

TEST FOR CAPACITOR INDUCTANCE IN THE RANGE OF 6 TO 18 Mc/s

C-1. OPERATING SEQUENCE (*See* Fig. 3)

C-1.1 Adjust the oscillator to the desired frequency by manipulating capacitor C_1.

C-1.2 Place shorting link across terminals *X* and adjust calibrated variable capacitors C_6 and C_5 to the maximum deflection of meter A.

C-1.3 Determine tare inductance L_t equivalent to L_1, meter A and connections by calculation from capacitance C_5 plus C_6 and the operating frequency.

C-1.4 Insert capacitor at terminals *X* and re-balance C_5 and C_6 for maximum deflection on meter A.

C-1.5 From the new reading of capacitance C_5 plus C_6 determine the new inductance. Where the test capacitor is large in comparison to C_5 plus C_6 the indutance of the unknown capacitor is determined by subtracting tare inductance (L_t) from the inductance of the circuit with the test capacitor connected.

C-1.6 When the test capacitor is of the same order of capacitances as C_5 plus C_6 the effective capacitance (C_x) of the test capacitor and the calibrated

variable capacitor in series should be calculated. From this calculated capacitance determine the inductance of the circuit (L_c) including the test capacitor. The inductance of the test capacitor is $L_c - L_t$.

V_1 = QY4-250 (CV2131)
L_1 = 5 microhenry tank coil 3·2 mm diameter copper tube
L_2 = 0·25 microhenry coupling coil 3·2 mm diameter copper tube
C_1 = 20-200 pF variable capacitor, 1·5 mm spacing
C_2 = 390 pF mica capacitor 2 500 V
C_3 = 390 pF mica capacitor 2 500 V
C_4 = 0·01 μF 630 V mica capacitor
C_5 = 20-2 200 pF variable capacitor
C_6 = 5-140 pF midget variable capacitor
R_1 = 10 000 ohm 5 watt wirewound resistor
A = 0-5 A thermocouple ammeter
X = Terminals for insertion of test capacitor

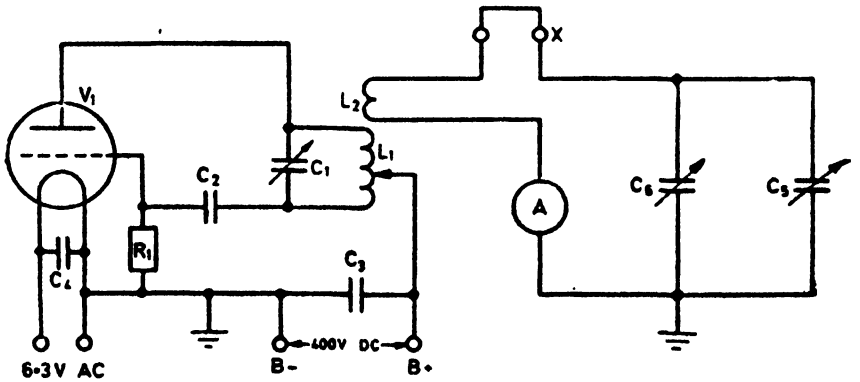


FIG. 3 CIRCUIT FOR MEASUREMENT OF INDUCTANCE

APPENDIX D

(*Clause* 7.3.6)

TEST FOR OUTER FOIL INDICATION (FOR TUBULAR CAPACITORS ONLY)

D-1. The correct indication of the termination which is connected to the outside metal foil shall be checked in such a way that the capacitor is not damaged. A suitable method is shown in Fig. 4.

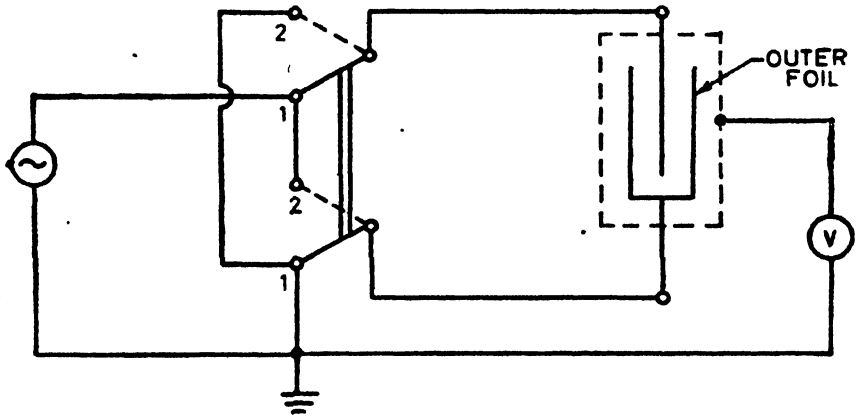


FIG. 4 ARRANGEMENT FOR CHECKING OUTER FOIL INDICATION

D-2. With the switch in position 1, the deflection of the voltmeter shall be markedly less than with the switch in position 2.

D-3. The frequency of the ac generator may be from 50 c/s to a few thousand cycles per second and shall be so chosen as to give a clear result of the measurement, the most appropriate value being dependent on the type of capacitor under test. The voltage shall be of the order of 10 V. The voltmeter shall have input impedance of approximately one megohm or higher. The stray capacitances of the wiring shall be kept low.

D-4. In the case of metal encased capacitors, the outer metal case shall be connected to the voltmeter. In the case of moulded type capacitors, an external metal foil shall be wrapped for this purpose.

APPENDIX E

(Clause 7.3.7)

METHOD OF TESTING SELF-HEALING PROPERTIES

E-0. GENERAL

E-0.1 The most important property of metallized paper capacitors is the property of self-healing under slight excess voltage. If the voltage across the capacitor is gradually raised, a value will be reached at which sparking occurs, and if the voltage is maintained at this value, the sparking will be only momentary. This sparking occurs at points of dielectric weakness in

the paper and the thin metal film is evaporated from these spots without damaging the paper. With aluminium film the high temperature will produce aluminium oxide, which is itself a good insulator. The electrical strength of the paper dielectric will, therefore, be restored almost immediately. The voltage can then be increased to a higher value when further momentary sparking will occur. A point is finally reached when sparking becomes continuous and breakdown occurs. The maximum voltage at which this self-healing action may occur without detriment to the properties of the capacitor is termed as the 'test voltage' and is approximately 1·5 times the working voltage. The maximum short-term voltage (applied for less than 10 seconds) which can be applied without destroying the capacitor is termed as the 'spark voltage' and is approximately 1·75 times the working voltage. Care must, therefore, be taken to ensure that metallized-paper capacitors are not subjected to continuous voltage overloading.

E-1. PRELIMINARY OPERATIONS

E-1.1 A dc voltage of 0·5 U_c is applied to the capacitor through a series resistor of such a value that the product of the resistance value and the rated capacitance is not less than one second.

E-1.2 The capacitor is then brought to its maximum category temperature.

E-1.3 As soon as the capacitor has reached its maximum category temperature, the applied voltage is raised to 1·25 U_c.

E-1.4 At that moment the test proper begins.

E-2. TEST CONDITIONS

E-2.1 The applied voltage shall be increased every 5 minutes by 12·5 percent of U_c up to the maximum value given in the following table:

Rated Voltage	*Maximum Test Voltage*
Less than 1 000 V	2·5 U_c
From 1 000 V to 2 000 V	2 U_c
More than 2 000 V	1·5 U_c

E-2.2 The capacitors shall be connected to a detection circuit for self-healing breakdowns, the sensitivity of which lies between $0{\cdot}1 \times 10^{-3}$ and $0{\cdot}3 \times 10^{-3}$ of category voltage. The complete circuit shall be properly screened so as to avoid interference from external sources.

E-2.3 The number of self-healing breakdowns shall be counted from the time where the test begins.

E-2.4 The test shall be stopped when any of the following conditions is fulfilled:

a) 25 breakdowns per 10 μF have occurred;

b) six hours have passed from the beginning of the test and at least three breakdowns per 10 μF have occurred; and

c) the test shall be stopped at the end of 24 hours.

E-3. FINAL MEASUREMENTS

E-3.1 The capacitor shall be allowed to cool to standard temperature for testing.

E-3.2 The capacitor shall be visually examined. There shall be no sign of deterioration.

E-3.3 The insulation resistance shall be measured. It shall be not less than 70 percent of the limits specified in **7.3.4.**

NOTE — Capacitors of 4·7 μF and less may be tested when connected in parallel with one detection circuit, on the condition that they are connected in series with an individual resistance such that the product of resistance and rated capacitance of each capacitor is not less than 1 ms. The group should have a series resistor as specified in **7.3.4.**

APPENDIX F

(*Clause* 7.7)

DETECTION OF SELF-HEALING FAILURES

F-1. The performance of the apparatus for the detection of self-healing failures may be as follows:

a) *Sensitivity* — For test the sensitivity has to be adjusted to respond to input pulses of 0·1 V,

b) *Duration of pulses* — The circuit shall respond to pulses having a duration greater than 10 μs,

c) *Repetition rate* — The circuit shall respond to a repetition rate of at least 10 pulses per second without considerable loss of sensitivity, and

d) *Time constant* — The time constant for the charge circuit of the capacitor shall be not greater than 0·1 second.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	*Unit*	*Symbol*
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	*Unit*	*Symbol*
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	*Unit*	*Symbol*	*Conversion*
Force	newton	N	1 N = 1 kg.1 m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2

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